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Predicting Park & Ride use: Traffic models extended using willingness-to-pay values for P&R provisions and services

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Summary

In order to enable more accurate P&R use predictions, standard traffic models were extended with information about the comfort of transferring between car and public transport at a P&R facility. In addition some other model specifications were added to improve the predictive validity of the original models. This extended P&R traffic model, applied in the region of Rotterdam, was able to make more truthful predictions of the number of car drivers switching mode that can be expected after introducing new P&R facilities in a certain area.

1 Introduction

Park and Ride (P&R) facilities are often introduced to cope with accessibility problems in urban areas, characterized by congestion and parking difficulties. However, existing P&R facilities do not always attract the intended number of car drivers. The planning of more frequently used P&R facilities may require more sophisticated traffic models being able to predict travellers' choices between the car, the P&R and the current public transport (PT) alternative.

Standard traffic models provide only limited insight in the trade-offs that car drivers make between attributes describing the P&R, the car and the current PT alternative (De Graaf *et al.*, 2005; Goudappel Coffeng BV, 2004). When extending these traffic models with comfort aspects being of influence on travellers' choices it is assumed that more adequate predictions of P&R use are within the range of possibility. The comfort attributes being of most importance are supervision, maintenance, safety of pedestrian route, availability of additional provisions such as a kiosk or a supermarket, the walking time between the car and the connecting public transport, the availability of a (heated) waiting room and the type of payment facilities (see Bos, 2004; Bos *et al.*, 2004).

This paper attempts to answer three research questions:

- (1) Which procedure has to be followed to incorporate the willingness-to-pay values in a more sophisticated traffic model?
- (2) What are the willingness-to-pay values for the mentioned comfort attributes?
- (3) Does the more sophisticated traffic model perform better than a traditional one?

These three questions form the basic structure of this paper. Section 2 presents the procedure of extending standard traffic models to optimise P&R predictions. Section 3 describes the derivation of the value of pay measures for the several comfort attributes. Section 4 compares the performance of the obtained sophisticated P&R traffic model with that of the standard traffic model for the city of Rotterdam. Finally, section 5 draws some conclusions.

2 Procedure to extend standard traffic models to optimise P&R predictions

Standard traffic models are able to calculate the resistances in terms of generalised costs of the car and the public transport alternative for all origin-destination relationships. To obtain a traffic model in which also the P&R alternative is included as travel option, the resistance to use the P&R alternative is modelled by adding the resistance of travelling by car from origin until the pre-selected P&R facilities to the resistance of travelling by public transport from the pre-selected P&R facilities until destination. In this way, a traffic model which includes only information about car and public transport resistances can be used to gain insight in travel resistances when using a multimodal P&R alternative.

However, when applying this procedure the resistance of the transfer between the car and the connecting public transport is not taken into account. As the resistance of the transfer at the P&R facility is also an important factor for travellers to choose for that alternative, also willingness-to-pay values for aspects describing the quality of the P&R facility should be incorporated into the extended P&R traffic model as being generalised costs. When including these aspects, the P&R traffic model is able to calculate for each origin-destination relationship the generalised costs of each of the available alternatives taking the comfort level of the P&R alternative into consideration. Consequently, for each relationship the modal shift can be calculated between the P&R alternative, the car alternative and the current door-to-door public transport alternative. When taking all possible origin-destination relationships into account, one is able to predict the number of car drivers switching mode for all P&R facilities included in the model. In the original model the choice for one of two competing facilities was only made based on distance and costs, while the introduction of the quality aspects adds a third important component.

Besides introducing quality aspects of the P&R alternative in the traffic model as resistance factors, the traffic model for the Rotterdam region was extended in two other ways. Firstly, the parking capacity of the P&R facility and the destination and the congestion on the road network were included as constraints in the model. Secondly, the mutual influence of the P&R facilities in the Rotterdam region was studied as P&R facilities situated close to each other might strengthen or compete with each other. When one P&R facility is occupied one might switch to another. However, if the detour time to another P&R facility will be too large then car drivers will decide to continue their trip by car anyway.

3 Deriving willingness-to-pay values: trade-offs between P&R characteristics

In order to obtain the willingness-to-pay values for the several comfort attributes, the model results of a comprehensive stated choice experiment regarding P&R choices were used (see Bos, 2004). This experiment was based on the hierarchical information integration (HII) approach (Louviere, 1994), an extension of the standard stated preference approach, used in order to take a large number of relevant attributes into consideration. To that end, HII assumes that individuals, when confronted with decisions that involve many attributes, process information in a hierarchical manner. This implies that individuals first group the attributes that belong together into higher-order decision constructs. Then, they evaluate each construct separately, and finally integrate these evaluations to arrive at an overall preference or choice. In line with these assumptions, separate experiments for each decision construct and an additional experiment are constructed based on empirical evidence to measure the integration of the construct evaluations (e.g. Louviere, 1984; Louviere and Timmermans, 1990; 1992). Based on the responses observed in each experiment, a utility model is estimated for each decision construct. Furthermore, an overall bridging model is estimated which links the separate construct evaluations with the overall evaluation or choice.

Figure 1 shows that two decision constructs were considered i.e. *Quality of P&R facility* and *Quality of connecting public transport*. Moreover a bridging experiment was performed in order to link the two decision constructs and to enable to take time and costs aspects into account. Moreover, this figure shows the relative importance scores of the different attributes included in the HII model. The specific part-worth utilities of this comprehensive HII model which were used to calculate the relative importance scores are reported in Bos (2004).

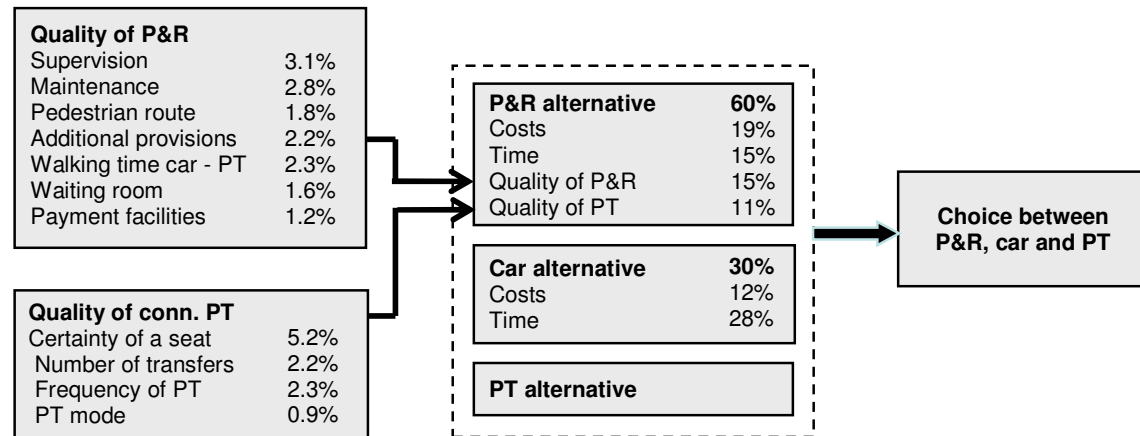


Figure 1: Importance of attributes included in HII experiment

As the experiments for the two decision constructs were linked to the bridging experiment where trade-offs had to be made between costs and the quality of the P&R facility and the connecting public transport, it was possible to derive the willingness-to-pay values for all attribute levels included in the experiments for the two decision constructs. The procedure of deriving willingness-to-pay values from results of the HII experiment is described by Bos and Van Wee (2005). Table 1 reports the willingness-to-pay values for only the decision construct *Quality of P&R facility* as these values were used to obtain insight into the generalised costs of the transfer between the car and the connecting public transport.

Table 1: Willingness-to-pay values for *Quality of P&R facility*

Decision construct P&R					
$R^2 = 0.17$; $n = 480$					
Supervision	No supervision	€ 0.00	Add. provisions	No	€ 0.00
	Cameras	€ 0.62		Kiosk	€ 0.20
	Cameras and supervisors	€ 0.79		Supermarket	€ 0.56
Maintenance	Good state of repair	€ 0.71	Waiting room	No	€ 0.00
	Holes in asphalt	€ 0.00		Covered / unheated	€ 0.33
	Graffiti / holes in asphalt	€ 0.00		Covered / heated	€ 0.41
Walking time car-PT	1 min	€ 0.58	Payment facilities	Machine	€ 0.29
	3 min	€ 0.44		Manned service	€ 0.06
	5 min	€ 0.00		Chipcard	€ 0.00
Pedestrian route	Obscure / deserted	€ 0.00			
	Open / deserted	€ 0.20			
	Open / well-populated	€ 0.45			

The willingness-to-pay values in Table 1 clearly shows that the four attributes relating to the general notion of (social) safety have higher willingness-to-pay values and are thus more important than the attributes describing the additional provision level.

Supervision at P&R is the most important attribute. However, car drivers are more willing to pay for installing cameras at the P&R facility compared to a P&R facility without supervision

than for the additional presence of supervisors. Moreover, the willingness-to-pay for a clean, well-maintained facility is high compared to a P&R facility with holes in asphalt. Apparently, one is not willing to pay extra for a P&R facility without graffiti. In addition, the increase of the willingness-to-pay for a walking time from the parking lots to the public transport stop from 1 to 3 minutes is smaller than the increase of the willingness-to-pay of a walking time from 5 to 3 minutes. Apparently, if one is required to walk more than 3 minutes, the utility of using the P&R alternative is decreasing rapidly. As expected, if the walking route is open and well-populated one is also willing to pay a relatively high amount of money.

Among the various attributes describing the additional provision level, Table 1 shows that one prefers a kiosk in a smaller degree than the availability of a supermarket. Probably, one is willing to pay a larger amount of money when one is able to combine some activities at the P&R facility. In addition, one is willing to pay a relatively large amount for a waiting room, even when this waiting room is not heated. Finally, realising a paying machine adds to motivate car drivers to transfer at the P&R facility.

Thus, beside the time and costs components, the quality aspects describing the P&R facility were introduced as resistance factors in the P&R traffic model. The resistance factors for the quality of the P&R facility were assumed to be zero in the most favourable circumstances. For example, when travellers are willing to pay € 0.79 for a P&R supervised both by cameras and by personal supervisors, the resistance to have no supervision at a P&R facility at all is € 0.79.

4 Performance of extended P&R traffic model for the region of Rotterdam

To gain insight whether the extended model does make better predictions of P&R use, the extended P&R traffic model was used to predict the number of car drivers switching mode for a selection of six P&R facilities in the North-Eastern part of the city of Rotterdam (see Figure 2). The reason to choose for this case is that Rotterdam has large experience with the P&R concept.



Figure 2: Locations of P&R facilities in Rotterdam

Before the prediction of the number of users on the P&R lots could be applied to a future situation, a calibration took place on the situation in 2004. This calibration is needed to calculate the required parameters of the P&R impedance and distribution function. After

having collected the correct parameters, the model was run and calculated a total number of 2055 users in a year while a total number of 1902 transferees were counted. While the absolute number of predicted P&R users was quite accurate, the relative number was even more precise. Comparing these results with the predictions of the standard P&R traffic model, the latter model provided predictions being deviating from the actual P&R use in a considerably larger degree (see De Graaf, 2004).

Figure 3 compares the counted number of car drivers switching mode at the six pre-selected P&R facilities with the number of car drivers switching mode according to the extended P&R traffic model. The established small deviations between the real occupation levels and the calculated numbers of cars are good to declare. After having calibrated the model for a present situation the model was also used to predict the number of users in the future year 2010. For that year, a total number of 3219 users were calculated.

Although the calculated number of users were quite accurate, the results of the purpose partitioning were still disappointing. Most of the calculated users were commuters, while RP data revealed that there were also a great amount of people with shopping purpose. It might be concluded that the extended P&R traffic model is able to predict P&R use very well and that plausible estimations of future P&R use are possible. Therefore a reapplication of the Rotterdam model with further improvements is currently being made for all 38 future P&R lots in the region. We hope to publish the results of this reapplication in the near future.

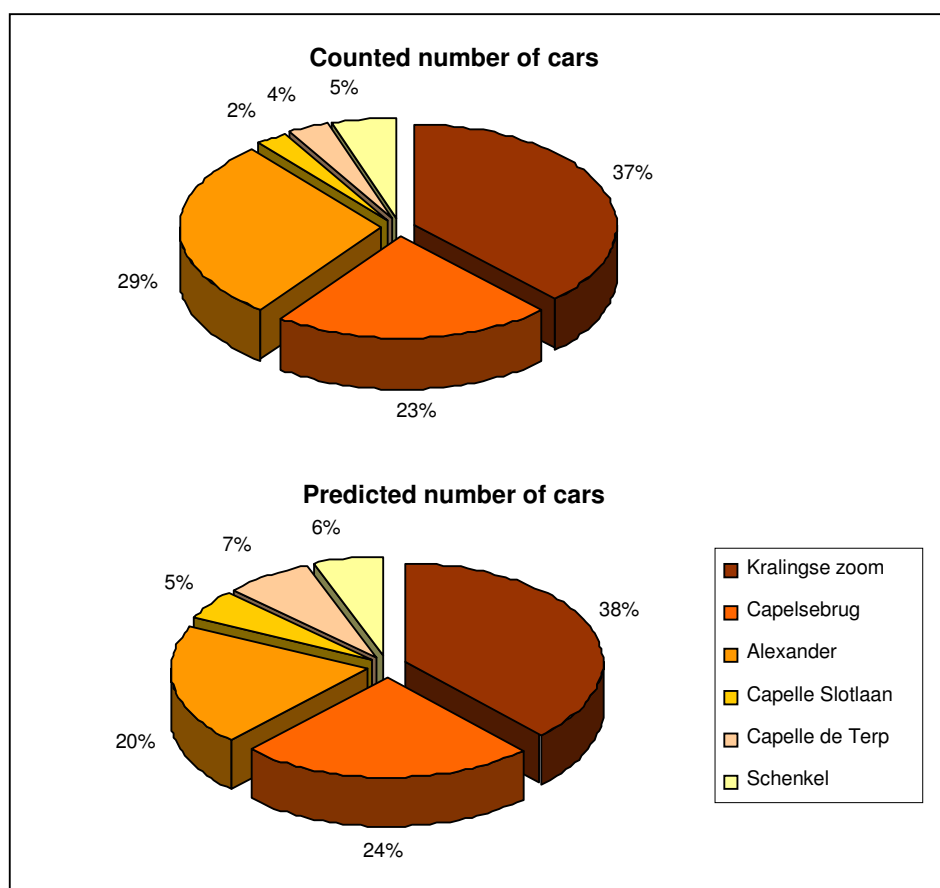


Figure 3: Comparison between the predicted and counted number of cars at the six P&R facilities in Rotterdam

5 Conclusions

In order to enable more accurate P&R use predictions, standard traffic models were extended with information about the comfort of transferring between car and public transport at a P&R facility. Moreover some other model specifications were added to improve the predictive validity of the original models. This extended P&R traffic model was applied in the region of Rotterdam.

The extended P&R traffic model gives insight into the preferences and choices of car drivers with respect to an unlimited number of P&R facilities and the car. These choices are thus based on the quality level of the separate P&R locations and take also factors into account such as the congestion level from the P&R facility until the destination and the number of parking lots at destination.

It can be concluded that the extended P&R traffic model is able to make more truthful predictions of the number of car drivers switching mode that can be expected after introducing new P&R facilities in a certain area. Therefore, the new developed method is a very strong improvement with respect to formerly used methods. The ability to simulate the mutual influence of different P&R facilities even strengthens this statement. The extended P&R traffic model thus offers many perspective for further application within the Netherlands and abroad.

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References

- Bos, D.M. (2004). *Changing Seats: A behavioural analysis of P&R use*. Delft.
- Bos, I.D.M., Van der Heijden, R.E.C.M., Molin, E.J.E. & Timmermans, H.J.P. (2004). "The Choice of Park & Ride Facilities: An Analysis Using a Context-Dependent Hierarchical Choice Experiment". *Environment and Planning A*. 36 (9): 1673-1686.
- Bos, I., E. Molin, H. Timmermans and R. van der Heijden (2003). "Cognitions and Relative Importances Underlying Consumer Valuation of Park and Ride facilities". *Transportation Research Record*. 1835: 121-127.
- Bos, D.M., E.J.E. Molin, R.E.C.M. van der Heijden (2002). "User-based definition of higher-order decision constructs to model preferences for P&R transfer points". *Urban Transport and the Environment in the 21st century*. Urban Transport VIII, Southampton: 417-426.
- Bos, I. and B. van Wee (2005), "Betalingsbereidheid voor voorzieningen en diensten op een P+R faciliteit". *Tijdschrift Vervoerswetenschap* 41 (1): 20-25.
- Edwin Hull Associates (1998). "Application of a Park-and-Ride Forecasting Procedure in the Greater Vancouver Transportation Model". *The 13th Annual International EMME/2 Users' Group Conference*. Houston, Texas, USA.
- Goudappel Coffeng BV (2004). *P+R-modellering: een optimalisatie van de bestaande modelleringstechniek*. Deventer.
- Graaf, S.W. de, W.J. de Kruijf, G. Wijnja, I. Bos, H. Lodder (2005), "Rekenmodel plaatst P+R in netwerkperspectief". *Verkeerskunde* 1: 24-29
- Louviere, J.J. (1984). "Hierarchical information integration: a new method for the design and analysis of complex multiattribute judgement problems". *Advances in Consumer Research*. XI: 148-155.
- Louviere, J.J., H.J.P. Timmermans (1990). "Hierarchical Information Integration Applied to Residential Choice Behavior". *Geographical Analysis*. 22 (2): 128-144.
- Louviere, J.J., H.J.P. Timmermans (1992). "Testing the external validity of hierarchical conjoint analysis models of recreational destination choice". *Leisure Science*. 14: 179-194.